

## International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693  
ISSN Online: 2617-4707  
NAAS Rating (2026): 5.29  
IJABR 2026; SP-10(4): 1156-1165  
[www.biochemjournal.com](http://www.biochemjournal.com)  
Received: 15-02-2026  
Accepted: 17-03-2026

**RT Waghmare**  
Nagarjun Medicinal and  
Aromatic Plant Garden, Dr.  
PDKV, Akola, Maharashtra,  
India

**Dr. SB Ammershettiwar**  
Nagarjun Medicinal and  
Aromatic Plant Garden, Dr.  
PDKV, Akola, Maharashtra,  
India

**Dr. MM Wakode**  
Nagarjun Medicinal and  
Aromatic Plant Garden, Dr.  
PDKV, Akola, Maharashtra,  
India

**Dr. AG Deshmukh**  
Nagarjun Medicinal and  
Aromatic Plant Garden, Dr.  
PDKV, Akola, Maharashtra,  
India

**Corresponding Author:**  
**RT Waghmare**  
Nagarjun Medicinal and  
Aromatic Plant Garden, Dr.  
PDKV, Akola, Maharashtra,  
India

## Evaluation of local cultures of safed musli (*Chlorophytum borivillianum*) for morphological parameters

**RT Waghmare, SB Ammershettiwar, MM Wakode and AG Deshmukh**

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i4Sn.8274>

### Abstract

This research study aimed to evaluate the morpho-physiological parameters of safed musli (*Chlorophytum borivillianum*) under different environmental conditions. The experiment involved measuring Plant height(cm), No. of leaves/plant, leaf area (cm), leaf length (cm), width of leaves (cm), specific leaf weight (g/cm<sup>2</sup>), days to 50% flowering, Days to 100% senescence of leaves, length of flowering stalk (cm), No. of tuber, RWC of leaves (%), CGR, RGR, NAR, CCI Data analysis revealed significant differences in the morpho-physiological parameters of safed musli plants grown under different conditions. The results provide valuable insights into the growth and development of safed musli & have implications for its cultivation & management.

**Keywords:** Safed musli, morphophysiological parameters, cultivation, environmental conditions, *Chlorophytum borivillianum*

### 1. Introduction

*Chlorophytum borivillianum* ('Safed Musli'), belonging to monocotyledonous family Liliaceae. It is distributed throughout the tropical and sub-tropical parts of the world. Herbal drugs have been known for millennia and are now in great demand all over the world as a rich source of therapeutic agents for the cure of diseases and ailments. About 12.5% of the 4,22,000 plant species documented worldwide are reported to have medicinal values; but only a few hundred are known to be in cultivation (Rao *et al.*, 2004) <sup>[10]</sup>. In India over 6,000 plants are used in traditional folk and herbal medicines representing about 75% of the medicinal needs of third world (Sharma *et al.*, 2008) <sup>[11]</sup>. In recent years, this plant has gained much popularity due to its economic value. Safed Musli is known for its roots and saponin components that are associated with various medicinal properties. This plant is used in Indian medicinal system since the 11th century AD. In Ayurveda, Safed Musli is categorized as a 'Vajikaran Rasayan' and used to treat various diseases such as leucorrhoea, gonorrhoea, impotence, infertility, diarrhoea and dysentery. It is considered a "Divya Aushad" or white gold and used as a health-promoting drug or tonic in the ayurvedic medicinal system (Manish Grover, 2021) <sup>[6]</sup>. *C. borivillianum* is categorized as critically endangered status according to IUCN Red data list. (Bhat *et al.*, 2018; Gowthami *et al.*, 2021).

At present, the estimated global market demand and production are approximately 35,000 t/annum and 5,000 t/annum, respectively which fulfill less than 15% of the required demand. According to another report, the world demand of roots is close to 50,000 t/annum (Somanath, 2008) <sup>[12]</sup>. Of the available quantum of *C. borivillianum*, over 95% of it comes through wild harvesting; an act expressly prohibited by the various state governments. The current global trades in medicinal plants is more than \$60 billion rate of 7% per annum. India's current potential in global trade is Rs. 4.36 billion which is expected to rise to Rs. 222 billion by 2050 (Khanam *et al.*, 2013) <sup>[4]</sup>. Safed Musli is primarily grown in rainfed areas where water availability is limited. Understanding how the plant responds to this water scarcity is crucial for optimizing its growth and productivity. By studying morpho-physiological parameters such as leaf area, root length, and biomass accumulation, researchers can assess the plant's ability to adapt and survive under rainfed conditions. This knowledge can then be used to develop strategies to enhance the plant's water use efficiency and overall performance

## 2. Material and Methods

The experimental materials consisted of sixteen germplasm accession of (*Chlorophytum borivillianum*) planting material of safed musli have been collected from Nagarjuna medicinal and aromatic plants garden, Dr.PDKV Akola, during kharif season 2022 with the major objective of to evaluate safed musli cultures for morphophysiological cultures for morphophysiological traits, the accession were raised in randomized block design (RBD) with two replications. Each accession was raised no. of rows per entry ten by adopting a spacing of 30cm×10cm for proper growth and development of tubers, raised beds were prepared sowing done on 2<sup>nd</sup> July 2022 and tuber were sown by dibbling method. After the germination, gap filling was completed on 25<sup>th</sup> July, 2022. Then after full emergence thinning was carried out so as to maintain required no. of plants plot<sup>-1</sup>. When the leaves started yellowing and dried up from the collar part and fell off, at this time the crop was harvested. All the recommended agronomic packages and practices were adopted during the entire crop period. In each replications, five random plants were chosen for biometrical observations at the time of maturity.

### Morphological observations

#### Plant height (cm)

Plant height was recorded with the help of a meter scale in centimeters from the base of the plant to the topmost developing node.

#### Number of leaves per plant

Total number of leaves per plant of tagged plants was recorded by counting 5 sample plants from each treatment and averaged. Data were recorded at 30 and 60 DAP.

#### Leaf area per plant (cm<sup>2</sup>)

Leaf area of three randomly selected plants from each replication was measured by using the digital leaf area meter and their average values were worked out. The data were recorded at 30 and 60 DAP.

#### Leaf length (cm)

Leaf length was recorded at 30, 60 DAP. Leaf length of randomly selected observational plants and their leaf from each treatment and replication was recorded with the help of meter scale in centimeter from the base of plant to middle of plant.

#### Width of leaves (cm)

Width of leaves of randomly selected observational plants and their leaf width from each treatment and replication was recorded with the help of meter scale in centimeter from the base of plant to middle of plant.

#### Specific leaf weight (g/dm<sup>2</sup>)

Specific leaf weight is the ratio of leaf weight of plant to the leaf area of the plant. It indicates the relative thickness of the leaf SLW was calculated at 30 and 60 DAP. SLW was estimated as per the formula given by Dhopte and Livera (1989)<sup>[16]</sup>.

#### Days to 50% flowering

Here the number of days from sowing to the date on which fifty percent of plants were flowered was recorded. Then mean value was calculated and noted.

#### Days to 100% senescence of leaves

Days to 100% senescence of leaves of safed musli plant of tagged plants was recorded from each treatment and averaged. Data were recorded at proper stage.

#### Length of flowering stalk (cm)

Length of flowering stalk per plant of tagged plants was recorded by counting five sample plants flowering stalk from each treatment and averaged by using cm scale. Data were recorded at proper stage.

#### Number of flowers per plant

Here number of flowers from sowing date to the date on which number of flowers per plant were flowered per plant was recorded at proper stage. Then mean value was calculated and noted.

#### Root parameter

##### Number of tubers per plant

The total number of fingers/tubers per plant was recorded by counting of five tagged plants from each replication and average was worked out.

#### Length of tuber (mm)

The length of tubers (fingers) was measured to the nearest millimeter with the help of a digital vernier calliper of five sample plants from each replication and average was calculated.

#### Tuber width (mm)

The width or diameter of tuber/ finger was measured in nearest millimetre with the help of a digital vernier calliper from five sample plants from each treatment and average was calculated.

### Physiological observations

#### Relative water content of leaves (RWC) (%)

Relative water content was calculated with the equation given by Barrs and Weatherley, (1962)<sup>[17]</sup>.

#### Dry matter production (g)

##### Total leaf dry weight (g/plant)

To determine the total leaf dry weight (g/plant), three plants were randomly selected and uprooted from each net plot. leaf portion detached for stalk. Then let the samples air dry. After this kept the leaf samples in big brown paper bags and allowed to dry in poly house, till the constant weight achieved. Observations of total leaf dry weight were taken at 30, 60 DAP. Then by using weighing balance dry weight were recorded. Finally mean of dry weight noted in gram per plant.

##### Total dry matter (g/plant)

To determine the dry matter put the plant samples in big brown paper bags and allow them to dry in a hot air oven at 700 c, till the constant weight is achieved. Then by using weighing balance dry weights were recorded. Finally means of dry weight noted in grams per plant.

### Computations of growth parameters

#### Crop Growth Rate (CGR) (g m<sup>-2</sup> day<sup>-1</sup>)

The crop growth rate is calculated to estimate the production efficiency of the crop. It was calculated by using the formula given by D. J. Watson (1952).

**Relative Growth Rate (RGR) ( $\text{g g}^{-1} \text{day}^{-1}$ )**

Relative growth rate is the increment in per unit dry weight per unit time. The observations were taken at 30-45, 45-60 DAP. It is expressed as gram per gram per day. The relative growth rate is computed by using Fisher, s formula (1921).

**Net Assimilation Rate (NAR) ( $\text{g dm}^{-2} \text{day}^{-1}$ )**

Net assimilation rate is the rate of increase in dry weight per unit leaf area per unit time (Watson, 1952). It is expressed as  $\text{g dm}^{-2} \text{day}^{-1}$ .

**Statistical Analysis**

The analysis of variance was performed to test the significance of differences between the treatment for all the characters as per the methodology suggested by Panse and Sukhatme (1954)<sup>[9]</sup>.

**3. Results and Discussion****Morphological parameters****Plant height**

The data at 30 DAP under rainfed condition showed significant difference among genotype. MCB-405(31.92cm) recorded significantly higher Plant height followed by AKSM-6(30.98cm), AKSM-12(30.35cm), AKSM-8(30.9cm), AKSM-4(29.82cm), AKSM-7(29.32cm), AKSM-2(29.13cm), AKSM-9(28.66cm), AKSM-15(28.20cm), AKSM-1(28.18cm), AKSM-11(28.10cm) Significantly lowest plant height was noticed by the accession is AKSM-13(23.48cm), however AKSM-5(26.26cm), AKSM-14(26.27cm), AKSM-3(26.71cm) and AKSM-9(28.66cm) were found at par among themselves. The data at 60 DAP under rainfed condition showed significant difference among genotype, AKSM-11(35.84cm), recorded significantly higher Plant height over AKSM-13 followed by AKSM-10(34.70cm), AKSM-6(33.96cm), AKSM-12(33.75cm), AKSM-5(33.37cm), MCB-405(33.19cm) and AKSM-2(33.04cm) were found at par among themselves Significantly lowest plant height was noticed by the accession is AKSM-13(29.78cm), however AKSM-9(29.96cm), AKSM-15(30.82cm), AKSM-3(31.66cm), AKSM-4(31.69cm), AKSM-8(31.77cm), AKSM-14(31.99cm), AKSM-7(32.75cm) and AKSM-1(32.87cm) were found at par among themselves.

**Number of leaves/plant**

The data at 30 DAP under rainfed condition showed significant difference among genotypes AKSM-1(10.17) recorded significantly more number of leaves per plant followed by AKSM-12(9.89), AKSM-15(9.83cm), AKSM-10, AKSM-11 and MCB-405 each (9.67), AKSM-8(9.50), AKSM-14(8.83) and AKSM-3(8.80) and significantly lowest Number of leaves per plant was noticed in the accession is AKSM-2(7.17), however AKSM-6 and each AKSM-13 each (7.83), AKSM-7(8.00), AKSM-4(8.33), AKSM-5(8.50) and AKSM-9(8.67) were found at par among themselves. The data at 60 DAP under rainfed condition showed significant difference among genotypes. AKSM-8(11.17), and MCB-405(11.17) recorded significantly more number of leaves per plant followed by AKSM-1, AKSM-10 and AKSM-14 each (10.80), AKSM-7(10.67), AKSM-11(10.50) AKSM-15(9.83), AKSM-13(10.17) and significantly lowest number of leaves per plant was noticed in the accession is AKSM-2(8.80), however AKSM-9(9.00), AKSM-3 and AKSM-6 each (9.17), AKSM-12(9.30),

AKSM-4(9.33), AKSM-5 and AKSM-15 each (9.83) and AKSM-13(10.17) were found at par among themselves.

Safed musli being a green plant, undergoes Photosynthesis to produce energy rich organic compound. The leaves contain chlorophyll, which capture light energy & convert It into chemical energy through photosynthesis and yield of plant. So, number of leaves per plant is desirable attribute for higher biomass production and yield. Bordia *et al.*, (1995) studied collections of Safed musli particularly from Rajasthan species of different region and observed that number of leaves/ plant in RC-1 to RC-56 were (6.80-13.40).

**Leaf area ( $\text{cm}^2$ )**

The data at 30 DAP under rainfed condition showed significant difference among genotype, AKSM-2(30.57 $\text{cm}^2$ ) recorded significantly higher leaf area/plant followed by AKSM-6(30.51 $\text{cm}^2$ ), AKSM-1(29.63 $\text{cm}^2$ ), MCB-405(29.61 $\text{cm}^2$ ), AKSM-7(28.25 $\text{cm}^2$ ), AKSM-5(28.07 $\text{cm}^2$ ) however found at par among themselves. Significantly lower leaf area and significantly lowest leaf area was noticed by the accession AKSM-11(21.22 $\text{cm}^2$ ), however AKSM-13 (21.29 $\text{cm}^2$ ), AKSM-15(22.43 $\text{cm}^2$ ), AKSM-12(22.94 $\text{cm}^2$ ) and AKSM-10(23.31 $\text{cm}^2$ ), AKSM-14(23.97 $\text{cm}^2$ ), AKSM-4(24.18 $\text{cm}^2$ ), AKSM-8(25.78 $\text{cm}^2$ ), AKSM-3(26.08 $\text{cm}^2$ ) were found at par among themselves. The data at 45 DAP under rainfed condition showed best significant difference among genotypes. MCB-405(33.33 $\text{cm}^2$ ) recorded significantly superior leaf area/plant followed by AKSM-12(33.04 $\text{cm}^2$ ), AKSM-2(32.96 $\text{cm}^2$ ), AKSM-5(32.84 $\text{cm}^2$ ), AKSM-3(32.62 $\text{cm}^2$ ), AKSM-9(32.42 $\text{cm}^2$ ), AKSM-4 (32.25), AKSM-7 (31.91 $\text{cm}^2$ ), AKSM-1 (31.84 $\text{cm}^2$ ), AKSM-15 (31.26 $\text{cm}^2$ ), AKSM-14(31.14 $\text{cm}^2$ ) found at par among themselves. Significantly lowest leaf area was recorded by the accession is AKSM-8(28.61 $\text{cm}^2$ ), however, AKSM-13(28.79 $\text{cm}^2$ ), AKSM-11(29.66 $\text{cm}^2$ ), AKSM-6(30.06 $\text{cm}^2$ ), AKSM-10(30.31 $\text{cm}^2$ ) were found at par among themselves. The data at 60 DAP under rainfed condition showed significant differences among genotypes AKSM-6(48.43 $\text{cm}^2$ ) noted significantly more leaf area/plant followed by AKSM-1(46.52 $\text{cm}^2$ ), MCB-405(45.96 $\text{cm}^2$ ), AKSM-7(44.5 $\text{cm}^2$ ), AKSM-5(44.85 $\text{cm}^2$ ) and AKSM-3(41.5 $\text{cm}^2$ ) found at par among themselves. Significantly lowest leaf area was noted by the accession AKSM-13(36.10 $\text{cm}^2$ ), however, AKSM-12(38.26 $\text{cm}^2$ ), AKSM-14(38.93 $\text{cm}^2$ ), AKSM-10(39.16 $\text{cm}^2$ ), AKSM-2(39.36 $\text{cm}^2$ ), AKSM-15(39.45 $\text{cm}^2$ ), AKSM-9(40.06 $\text{cm}^2$ ), AKSM-11(40.74 $\text{cm}^2$ ), AKSM-8(40.8 $\text{cm}^2$ ), AKSM-4(41.21 $\text{cm}^2$ ) and AKSM-3(41.51 $\text{cm}^2$ ) however were found at par among themselves. Present data showed increase in morph-physiological character like leaf area which may be because of increase in activities of metabolism and released photosynthates which enhanced plant growth which came up with increase in leaf length which might contribute to increase in leaf area and this finding in genotypes under semi-arid conditions leaf area (37.49-38.84 $\text{cm}^2$ ) reported that Hemlata Bharti *et.al*,

**Leaf length (cm)**

The data at 30 DAP under rainfed condition showed significant difference among genotype, AKSM-6(21.96cm) recorded best significantly more leaf length followed by AKSM-1(21.78cm), AKSM-7(21.58cm) found at par among themselves. Significantly lowest leaf length was noticed in

the accession is AKSM-3(14.64cm), however AKSM-13(15.43cm) were found at par with each other followed by AKSM-15(16.87cm), AKSM-8(17.12cm), AKSM-9(17.32cm), AKSM-12(17.67cm), AKSM-14(17.78cm), AKSM-10 and AKSM-11 each (18.39cm), AKSM-4(18.49cm), MCB-405(18.72cm), AKSM-5(19.20cm), AKSM-2(19.21cm). The data at 60 DAP under rainfed condition showed significant difference among genotypes. AKSM-7(25.07cm) recorded significantly highest leaf length followed by AKSM-6(24.78cm) and AKSM-1(24.43cm) and were found at par among themselves. Significantly lowest leaf length was noticed by the accession is AKSM-3(18.58cm), followed by AKSM-13(20.16cm) found at par with each other followed by AKSM-15(21.34cm), AKSM-14(21.45cm), AKSM-8 (21.56cm), AKSM-12(21.86cm), AKSM-9(21.98cm), AKSM-4 (22.32cm), AKSM-10 (22.43cm), AKSM-2(22.44cm), MCB-405 (22.60cm), AKSM-11(22.65cm) and AKSM-5(23.10cm) were found at par among themselves. The maximum per cent as per wards upto increase in leaf length with respect to days after planting is more during first 30 DAP and 60 DAP when compared with it. In under rainfed conditions, the increase in leaf length after planting is primarily due to cell elongation and expansion. As the plant absorbs water from the soil, the cells in the leaves will expand, causing the leaves to grow longer. This process is regulated by plant hormones such as auxins, which stimulate cell elongation and growth. The plant may also undergo processes such as photosynthesis and respiration to produce the energy needed for growth. The leaf length was profoundly affect a variety of biological processes, for instance, plant growth, survival, reproduction and ecosystem function. Leaf length the longest extension from leaf apex to base. These are in accordance with the finding of Trivedi *et.al* under Collection and evaluation of *Chlorophytum* species in Indore who evaluated difference in leaf length (15.93-63.18cm).

### Leaf width (cm)

The data at 30 DAP under rainfed condition showed significant difference among genotype, AKSM-2(1.69cm) recorded best significantly superior width of leaves than all the genotypes under study. Significantly lowest width of leaves was noticed by the accession AKSM-11(1.17cm), however AKSM-10(1.21cm), AKSM-4(1.28) AKSM-14 and AKSM-15(1.31cm), AKSM-12(1.32cm), AKSM-7(1.34cm), AKSM-6(1.37cm), AKSM-1 and AKSM-9(1.39cm) and found at par among themselves followed by AKSM-5(1.46cm), AKSM-3(1.46cm), AKSM-8(1.49cm) and MCB-405(1.59cm).

The data at 60 DAP under rainfed condition showed non-significant difference among genotype, MCB-405(2.03cm) recorded non-significantly more width of leaves followed by AKSM-3(1.97cm), AKSM-5(1.92cm), AKSM-1 and AKSM-4 each with (1.86cm), AKSM-15(1.85cm), AKSM-9(1.84cm), AKSM-14(1.82cm), AKSM-13(1.80cm), AKSM-7(1.79cm), AKSM-12(1.76cm), AKSM-2 and AKSM-10 each (1.74cm) were found at par among themselves and non-significantly lowest width of leaves was noticed in the accession is AKSM-11(1.71cm).

The per cent increase in width of leaves with respect to days after planting upto 30 DAP is significant and from 60 DAP was minimum. Because of Cell expansion (The cells within the leaf tissue are actively taking up water and expanding,

leading to an increase in leaf width.), Photosynthesis(The newly planted leaf is likely to be actively engaging in photosynthesis, producing sugars and other compounds that contribute to cell growth and expansion.), Water uptake(The newly planted leaf is absorbing water from the surrounding soil, leading to turgor pressure within the cells and contributing to the increase in leaf width.), Hormonal activity(Plant hormones such as auxins and cytokinins may be involved in regulating cell expansion and growth, contributing to the increase in leaf width.) These physiological activities work together to support the rapid growth and expansion of the newly planted leaf, leading to the observed increase in leaf width Bordia *et al.*, (1995) also reported during collections of Safed musli particularly Rajasthan species of different region and observed that leaf width RC-1 to RC-56(1.06-1.75cm).

### Specific leaf weight (g/dm<sup>2</sup>/plant)

The data at 30 DAP under rainfed condition showed significant difference among genotype, AKSM-8(0.077 g/dm<sup>2</sup>/plant) recorded significantly more Specific leaf weight followed by MCB-405(0.075 g/dm<sup>2</sup>/plant), AKSM-9(0.074 g/dm<sup>2</sup>/plant), AKSM-6(0.070 g/dm<sup>2</sup>/plant), AKSM-14(0.068 g/dm<sup>2</sup>/plant) and AKSM-3(0.068 g/dm<sup>2</sup>/plant), AKSM-13(0.066 g/dm<sup>2</sup>/plant) found at par among themselves. Significantly lowest Specific leaf weight was recorded by the accession AKSM-2(0.047 g/dm<sup>2</sup>/plant), however AKSM-1(0.053 g/dm<sup>2</sup>/plant), AKSM-4 and AKSM-7 each (0.054 g/dm<sup>2</sup>/plant), AKSM-5(0.056 g/dm<sup>2</sup>/plant), AKSM-11(0.058 g/dm<sup>2</sup>/plant) found at par among themselves lowed AKSM-15(0.063 g/dm<sup>2</sup>/plant), AKSM-10 and AKSM-12 each (0.064 g/dm<sup>2</sup>/plant) were found at par among themselves.

The data at 60 DAP under rainfed condition showed significant difference among genotype MCB-405(0.109 g/dm<sup>2</sup>/plant) recorded significantly superior Specific leaf weight followed by AKSM-10(0.096 g/dm<sup>2</sup>/plant) and found at par with each significantly lowest Specific leaf weight was recorded by the accession AKSM-1(0.062 g/dm<sup>2</sup>/plant), however AKSM-6(0.066 g/dm<sup>2</sup>/plant), AKSM-5 and AKSM-9(0.071 g/dm<sup>2</sup>/plant), AKSM-11(0.072 g/dm<sup>2</sup>/plant), AKSM-4(0.072 g/dm<sup>2</sup>/plant), AKSM-3(0.073 g/dm<sup>2</sup>/plant), AKSM-7(0.076 g/dm<sup>2</sup>/plant), AKSM-8(0.077 g/dm<sup>2</sup>/plant) found at par among themselves. AKSM-2(0.080 g/dm<sup>2</sup>/plant), AKSM-15(0.081 g/dm<sup>2</sup>/plant), AKSM-12(0.082 g/dm<sup>2</sup>/plant), AKSM-13(0.087 g/dm<sup>2</sup>/plant) were found at par among themselves. Specific leaf weight (SLW) indicates the thickness of leaf and is known to have positive correlation with photosynthetic rate (Walter *et al*).

### Days to 50% flowering

The data at proper stage under rainfed condition showed significant difference among genotype AKSM-6, AKSM-11, AKSM-15 each (35 days), recorded significantly more days to 50 % flowering followed by AKSM-1 and AKSM-10(34), AKSM-2, AKSM-5 and AKSM-8 each (32 days), AKSM-4, AKSM-7 and AKSM-9each (31 days), AKSM-3, AKSM-13 and AKSM-14(30 days) were found at par among themselves and significantly lowest days to 50 % flowering was recorded by the accession MCB-405(25 days), however AKSM-12(28 days) were found at par among themselves.

The reason for the 50% flowering occurring relatively soon after sowing could be due to the specific growth conditions, such as temperature, soil moisture, and nutrient availability,

which are optimal for the plant's rapid growth and development.

**Table 1:** Evaluation of local cultures of safed musli for morpho-physiological parameters

| Germplasm | Plant height |       | No. of leaves/plant |       | Leaf length (cm <sup>2</sup> ) |       | Leaf area (dm <sup>2</sup> ) |       | Width of leaves (cm) |      | Specific leaf weight (g/dm <sup>2</sup> /plant) |        |
|-----------|--------------|-------|---------------------|-------|--------------------------------|-------|------------------------------|-------|----------------------|------|-------------------------------------------------|--------|
|           | 30           | 60    | 30                  | 60    | 30                             | 60    | 45                           | 60    | 30                   | 60   | 30                                              | 60     |
| AKSM-1    | 28.18        | 32.87 | 10.17               | 10.80 | 21.78                          | 24.43 | 29.63                        | 31.84 | 1.39                 | 1.86 | 0.053                                           | 0.062  |
| AKSM-2    | 29.13        | 33.04 | 7.17                | 8.80  | 19.21                          | 22.44 | 30.57                        | 32.96 | 1.69                 | 1.74 | 0.047                                           | 0.080  |
| AKSM-3    | 26.71        | 31.66 | 8.80                | 9.17  | 14.64                          | 18.58 | 26.09                        | 32.62 | 1.46                 | 1.97 | 0.068                                           | 0.073  |
| AKSM-4    | 29.82        | 31.69 | 8.33                | 9.33  | 18.49                          | 22.32 | 24.18                        | 32.26 | 1.28                 | 1.86 | 0.054                                           | 0.072  |
| AKSM-5    | 26.26        | 33.37 | 8.50                | 9.88  | 19.20                          | 23.10 | 28.08                        | 32.84 | 1.46                 | 1.92 | 0.056                                           | 0.071  |
| AKSM-6    | 30.98        | 33.96 | 7.83                | 9.17  | 21.96                          | 24.78 | 30.51                        | 30.06 | 1.37                 | 1.88 | 0.070                                           | 0.066  |
| AKSM-7    | 29.32        | 32.75 | 8.00                | 10.67 | 21.58                          | 25.07 | 28.25                        | 31.91 | 1.34                 | 1.79 | 0.054                                           | 0.076  |
| AKSM-8    | 30.00        | 31.77 | 9.50                | 11.17 | 17.12                          | 21.56 | 25.79                        | 28.61 | 1.49                 | 1.90 | 0.077                                           | 0.076  |
| AKSM-9    | 28.66        | 29.96 | 8.67                | 8.95  | 17.32                          | 21.98 | 23.86                        | 32.42 | 1.39                 | 1.84 | 0.074                                           | 0.071  |
| AKSM-10   | 27.78        | 34.70 | 9.67                | 10.80 | 18.39                          | 22.43 | 23.32                        | 30.31 | 1.21                 | 1.74 | 0.064                                           | 0.096  |
| AKSM-11   | 28.10        | 35.84 | 9.67                | 10.50 | 18.39                          | 22.65 | 21.22                        | 29.66 | 1.17                 | 1.71 | 0.058                                           | 0.072  |
| AKSM-12   | 30.25        | 33.75 | 9.89                | 9.30  | 17.67                          | 21.86 | 22.94                        | 33.05 | 1.32                 | 1.76 | 0.064                                           | 0.082  |
| AKSM-13   | 23.48        | 29.78 | 7.83                | 10.17 | 15.43                          | 20.16 | 21.29                        | 28.79 | 1.30                 | 1.80 | 0.066                                           | 0.087  |
| AKSM-14   | 26.27        | 31.99 | 8.83                | 10.80 | 17.78                          | 21.45 | 23.98                        | 31.14 | 1.31                 | 1.82 | 0.068                                           | 0.070  |
| AKSM-15   | 28.20        | 30.82 | 9.83                | 9.80  | 16.87                          | 21.34 | 22.43                        | 31.26 | 1.31                 | 1.85 | 0.063                                           | 0.081  |
| MGB-405   | 31.92        | 33.19 | 9.67                | 11.17 | 18.72                          | 22.60 | 29.62                        | 33.33 | 1.59                 | 2.03 | 0.075                                           | 0.109  |
| F-test    | S            | S     | S                   | S     | S                              | S     | S                            | S     | S                    | NS   | S                                               | S      |
| SE(m)±    | 1.28         | 1.04  | 0.54                | 0.50  | 0.69                           | 0.80  | 0.81                         | 0.91  | 1.79                 | 0.03 | 0.10                                            | 0.004  |
| CD@5%     | 3.86         | 3.13  | 1.63                | 1.63  | 2.42                           | 2.42  | 2.29                         | 2.63  | 5.08                 | 0.09 | 0.29                                            | 0.0159 |

#### Days to 100% senescence

The data days to 100 % senescence of leaves under rainfed condition showed significant differences among genotype AKSM-10(84 days), recorded significantly more days to 100% senescence of leaves followed by AKSM-13(82.5 days), MCB-405(82 days), AKSM-5(81 days), AKSM-9 and AKSM-11(80.5 days), AKSM-12(79.5 days) were found at par among themselves. Significantly lowest days to 100% senescence of leaves was recorded by the accession is AKSM-2 and AKSM-8(68.5), however AKSM-7, AKSM-3 and AKSM-15(70.5 days), AKSM-14(73 days) found at par among themselves followed by genotypes AKSM-6(76.5 days), AKSM-1 and AKSM-4(77.5 days) were found at par among themselves.

#### Length of flowering stalk (cm)

The data at flowering under rainfed condition showed significant difference among genotype AKSM-8(22.20 cm), recorded significantly more length of flowering stalk followed by AKSM-2(21.48 cm), MCB-405(21.38 cm), AKSM-9(21.26 cm), AKSM-14(20.83 cm), AKSM-6(20.78 cm), AKSM-11(20 cm) however were found at par among themselves. Significantly lowest length of flowering stalk(cm) was recorded in the accession is AKSM-7(18.05 cm) however AKSM-1(18.2 cm), AKSM-13(18.66 cm), AKSM-10(18.69 cm), AKSM-5(18.73 cm), AKSM-15(19.14 cm), AKSM-3(19.26 cm), AKSM-4(19.35 cm) and AKSM-12(19.55 cm) were found at par among themselves. This observation was in association with the results noted by Hemlata Bharti, *et. al.* In multivariate analysis of yield associated traits in Safed musli (*Chlorophytum borivillianum*) genotypes under semi-arid conditions reported that the inflorescence length (cm) or Length of flowering stalk ranged from (2.14-37.04cm).

#### Number of flowers per plant

The data at flowering stage under rainfed condition showed significant difference among genotype AKSM-2, AKSM-6

and MCB-405(20.5 flowers), recorded significantly more number of flowers per plant followed by AKSM-6(20 flowers), AKSM-7 and AKSM-12 each (19 flowers), AKSM-8 and AKSM-11(18.5 flowers), AKSM-13(18 flowers), AKSM-1, AKSM-3 and AKSM-10 each (17.5 flowers), AKSM-11(18.5 flowers) however these were found at par among themselves. Significantly lowest number of flowers per plant was recorded by the accession AKSM-9 and AKSM-14 each (14.5 flowers) however AKSM-4 and AKSM-15(17 flowers) were found at par among themselves. The observation of the number of flowers on safed musli plants allows for an understanding of the plant's reproductive potential and potential seed production, while also providing insights into the physiological activities (cell division, differentiation, and pollination) involved in the development of flowers. Hemlata Bharti, *et. al* observe that the Multivariate analysis of yield associated traits in Safed musli (*Chlorophytum borivillianum*) genotypes under semi-arid conditions reported that the no. of flowers ranged from (3.20-29.80).

#### Number of tubers

The data at harvest under rainfed condition showed significant difference among genotype AKSM-8(12.90), recorded significantly more number of tubers per plant followed by MCB-405(12.10), AKSM-11(11.80) AKSM-3(11.70), AKSM-14(11.40), AKSM-1(11.35), AKSM-13(11.20), AKSM-2(11.10), AKSM-4(11.0), AKSM-5(10.9), AKSM-10(10.6) were found at par among themselves. Significantly lowest Number of tubers per plant was recorded by the accession is AKSM-9(7.60) followed by AKSM-12(8.90), AKSM-6(9.7), AKSM-15(10.05), AKSM-7(10.10) however, they were found at par among themselves. This observation was in association with the results noted by AA Mehta, *et al.* (2019) who observed that the great variability in number of tubers (9.5), (13.04), (7.10) Cluster II contained maximum number of accessions.

Maximum inter cluster distance was found between Cluster -II and Cluster-III genetic divergence study for growth

characters among the accessions of Safed Musli.



**Plate 1:** Experimental field at Nagarjuna medical and aromatic plant garden Dr. PDKV, Akola.



**Plate 2:** Plant height (cm) of safed musli



**Plate 3:** Number of leaves per plant



**Plate 4:** Width of leaves (cm) of safed musli



**Plate 5:** Days to 50% flowering of safed musli



**Plate 6:** Number of tubers per plant



**Plate 7:** Length of tubers (cm) of safed musli

**Table 2:** Evaluation of local cultures of safed musli for root parameters.

| Germplasm | No. of tubers/plant at harvest | Length of tuber at harvest | Width of tuber/plant at harvest | Fresh wt. of single tuber at harvest | Dry wt. of single tuber at harvest | Tuber yield g/plant at harvest | Tuber yield kg/plot at harvest | No. of seed/flower at harvest |
|-----------|--------------------------------|----------------------------|---------------------------------|--------------------------------------|------------------------------------|--------------------------------|--------------------------------|-------------------------------|
| AKSM-1    | 11.35                          | 3.99                       | 4.00                            | 1.21                                 | 0.30                               | 13.96                          | 0.41                           | 8.50                          |
| AKSM-2    | 11.10                          | 4.60                       | 6.40                            | 1.21                                 | 0.29                               | 13.92                          | 0.70                           | 10.00                         |
| AKSM-3    | 11.10                          | 4.25                       | 6.49                            | 1.11                                 | 0.30                               | 14.42                          | 1.01                           | 10.00                         |
| AKSM-4    | 11.00                          | 4.45                       | 6.34                            | 1.21                                 | 0.31                               | 10.12                          | 0.69                           | 10.00                         |
| AKSM-5    | 10.90                          | 4.81                       | 6.23                            | 1.17                                 | 0.27                               | 13.65                          | 0.57                           | 9.25                          |
| AKSM-6    | 9.70                           | 4.39                       | 6.13                            | 1.05                                 | 0.28                               | 11.68                          | 0.80                           | 9.75                          |
| AKSM-7    | 10.10                          | 5.37                       | 5.60                            | 1.07                                 | 0.30                               | 13.75                          | 0.75                           | 10.75                         |

|          |       |      |      |      |      |       |      |       |
|----------|-------|------|------|------|------|-------|------|-------|
| AKSM-8   | 12.90 | 4.69 | 6.27 | 1.43 | 0.30 | 14.81 | 1.04 | 9.50  |
| AKSM-9   | 7.60  | 4.13 | 5.64 | 1.22 | 0.29 | 9.34  | 0.52 | 9.00  |
| AKSM-10  | 10.60 | 4.17 | 6.06 | 1.05 | 0.30 | 10.91 | 0.56 | 10.50 |
| AKSM-11  | 11.80 | 3.79 | 6.39 | 1.12 | 0.30 | 12.94 | 0.72 | 8.75  |
| AKSM-12  | 8.90  | 2.82 | 6.29 | 0.83 | 0.31 | 7.08  | 0.36 | 11.50 |
| AKSM-13  | 11.20 | 3.64 | 6.14 | 0.92 | 0.28 | 11.99 | 0.42 | 8.75  |
| AKSM-14  | 11.40 | 3.43 | 6.31 | 0.97 | 0.29 | 10.43 | 0.39 | 8.50  |
| AKSM-15  | 10.05 | 3.90 | 5.83 | 1.05 | 0.22 | 11.57 | 0.52 | 9.00  |
| MCB-405  | 12.10 | 6.54 | 5.76 | 1.22 | 0.31 | 15.25 | 0.88 | 11.50 |
| F-Test   | S     | S    | S    | S    | S    | S     | S    | S     |
| SE(m) ±  | 0.83  | 0.30 | 0.29 | 0.08 | 0.01 | 0.91  | 0.04 | 0.25  |
| CD at 5% | 2.50  | 0.89 | 0.88 | 0.23 | 0.03 | 2.75  | 0.13 | 0.76  |



Plate 8: Width of tubers (mm)



Plate 9: Dry wt. of tubers (g/plant)



Plate 10: Chlorophyll content index

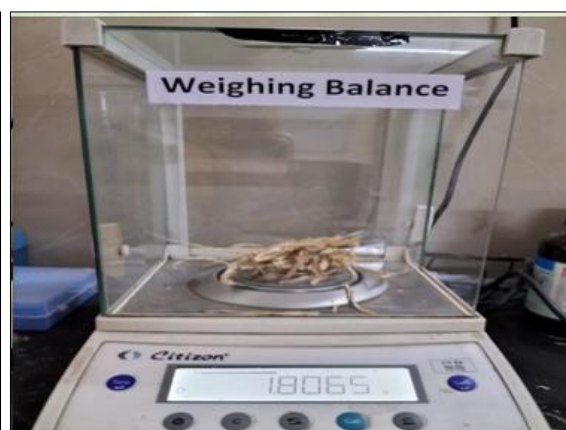
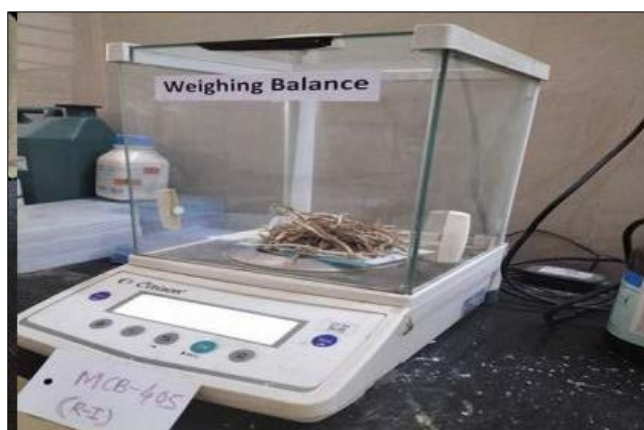


Plate 11: Dry weight of leaves (g/plant)

**Length of tubers (cm)**

The data at harvest under rainfed condition showed significant difference among genotypes MCB-405(6.54cm), recorded best significantly superior length of tubers per plant followed by AKSM-7(5.37 cm). Significantly lowest

Length of tubers per plant was recorded by the accession is AKSM-12(2.82cm) followed by AKSM-14(3.43cm), AKSM-13(3.64cm) and found at par among themselves by followed AKSM-11(3.79cm), AKSM-15(3.90cm), AKSM-1(3.99cm), AKSM-9(4.13cm), AKSM-10 and AKSM-10

each (4.17cm), AKSM-6(4.39cm), AKSM-4(4.45cm), AKSM-2(4.60cm), AKSM-8(4.69cm), AKSM-5(4.81cm) and were found at par among themselves. This observation was in association with the results noted by Bordia *et al.*, (1995) who studied extensive collections of safed musli from different district of Rajasthan and observed that length of tuber RC-1to RC-56(2.50-7.20cm).

#### Width of tubers (mm)

The data at harvest under rainfed condition showed significant difference among genotypes AKSM-3(6.49mm), recorded significantly more width of tuber per plant followed by AKSM-2 (6.40mm), AKSM-11(6.39mm), AKSM-4 (6.33mm), AKSM-14 (6.31mm), AKSM-12 (6.28mm), AKSM-8 (6.26mm), AKSM-5 (6.22mm), AKSM-13 (6.14mm), AKSM-6 (6.13mm), AKSM-10 (6.06mm), AKSM-15 (5.83mm), MCB-405 (5.76mm), AKSM-9 (5.64mm) however, these were found at par among themselves. Significantly lowest width of tuber per plant was recorded by the accession is AKSM-1(4mm) that all genotypes under study. Mehta, *et al.* (2019) observed the great variability in width of tubers (6.52), (6.53), (5.94) Cluster II contained maximum number of accessions. Maximum inter cluster distance was found between Cluster -II and Cluster-III in genetic divergence study for growth characters among the accessions of Safed Musli.

#### Physiological observations

##### Relative water content (RWC %)

The data at 30 DAP under rainfed condition showed significant difference among genotype. AKSM-1(52.75%) recorded significantly superior relative water content of leaves none of the genotypes surplus this genotypes under study followed by AKSM-15(48.31%). Significantly lowest relative water content of leaves was noticed by the accession AKSM-11(36.78%) followed by AKSM-7(38.87%), AKSM-10(39%) however they were found at par among themselves followed by AKSM-13(41.25%), AKSM-6(41.28%), AKSM-4(41.54%), AKSM-12(41.73%), AKSM-8(42.78%), AKSM-5(43.79%), AKSM-2(44.02%) found at par among themselves followed by AKSM-14(44.47%), AKSM-14(44.47%), AKSM-3(46.18%), MCB-405(47.46%) were found at par among themselves. The data at 60 DAP under rainfed condition showed significant differences among genotypes, AKSM-12(57.62%), recorded best significantly higher relative water content of leaves followed by AKSM-14(53.70%) found at par among themselves. Significantly lowest relative water content of leaves was noticed by the accession AKSM-13(43.00%) followed by AKSM-10(43.72%), AKSM-6(44.19%), AKSM-3(45.39%), AKSM-4(46.56%) however they were found at par among themselves followed by AKSM-2(48.38%), AKSM-1(48.89%), AKSM-5(49.06%), AKSM-11(49.08%), AKSM-8(49.33%), MCB-405(49.84%), AKSM-7(50.44%), AKSM-9(51.51%), AKSM-15(52.70%) however they were found at par among themselves.

In present investigation, leaf relative water content is said to be good indicator for screening of varieties/ genotypes for tolerance toward water stress. This is related with stomatal conductance. The function of stomata is to control water loss from the plant via transpiration. When  $k^+$  is deficient, the stomata cannot function properly and water losses from plant may reach damaging levels (Gething, 1990). Relative water content is one of the important traits that influence

plant water relation. Similar observations had been stated by Siddique *et al.*

#### Total leaf dry weight (g/plant)

The data at 30 DAP under rainfed condition showed significant difference among genotypes AKSM-6 and MCB-405 each (2.04 g/plant) recorded best significantly superior total leaf dry weight during early growth stage significantly lowest total leaf dry weight was noticed by the accession AKSM-13(1.23 g/plant) followed by AKSM-11(1.25 g/plant), AKSM-15(1.32 g/plant), AKSM-4(1.34 g/plant), AKSM-10(1.40 g/plant), AKSM-2(1.46 g/plant), AKSM-7(1.52 g/plant) however found at par among themselves followed by AKSM-14(1.58 g/plant), AKSM-12(1.62 g/plant), AKSM-5(1.65 g/plant), AKSM-9(1.68 g/plant), AKSM-8(1.71 g/plant), AKSM-1(1.73 g/plant), AKSM-3(1.75 g/plant) however they were found at par among themselves. The data at 60 DAP under rainfed condition showed significant difference among genotype. AKSM-10(3.71 g/plant) recorded significantly high total leaf dry weight followed by MCB-405(3.67 g/plant), AKSM-7(3.40 g/plant), AKSM-15(3.28 g/plant), AKSM-12(3.19 g/plant), AKSM-5 and AKSM-13 (3.18 g/plant), AKSM-8(3.12 g/plant), AKSM-3(3.05 g/plant), AKSM-7(3.04 g/plant), AKSM-2 and AKSM-11(2.88 g/plant), AKSM-9(2.87 g/plant), AKSM-14(2.76 g/plant) and highest significantly lowest total leaf dry weight was noticed in the accession is AKSM-1(2.49 g/plant).

#### Total dry matter (g/plant)

The data at 30 DAP under rainfed condition showed significant difference among genotypes, AKSM-3(6.31 g/plant) recorded significantly high total dry matter production followed by AKSM-5(5.61 g/plant), AKSM-7(5.53 g/plant), AKSM-1(5.38 g/plant), AKSM-9(5.29 g/plant), MCB-405(5.27 g/plant) AKSM-8(5.26 g/plant), AKSM-11(5.21 g/plant), AKSM-15(5.10 g/plant), AKSM-6(5.09 g/plant) however these were found at par among themselves. Significantly lowest total dry matter production was noticed by the accession AKSM-2(3.38 g/plant) followed by AKSM-14(3.70 g/plant), AKSM-13(3.80 g/plant), AKSM-4(4.34 g/plant) however found at par among themselves. AKSM-10(4.72 g/plant), AKSM-12(4.89 g/plant) and were found at par among themselves. The data at 45 DAP under rainfed condition showed significant difference among different genotypes. MCB-405(8.72 g/plant) recorded significantly higher total dry matter production followed by AKSM-15(8.04 g/plant), AKSM-5(7.90 g/plant), AKSM-1(7.86 g/plant), AKSM-10(7.80 g/plant), AKSM-8 (7.60 g/plant) however these were found at par among themselves. Significantly lowest total dry matter production was noticed in the accession is AKSM-13(5.03 g/plant) followed by AKSM-4(5.54 g/plant), AKSM-14(5.94 g/plant), AKSM-2(6.09 g/plant), AKSM-11(6.24 g/plant) however these were found at par among themselves followed by AKSM-9(6.62 g/plant), AKSM-12(7.00 g/plant), AKSM-6 and AKSM-7(7.22 g/plant), AKSM-3(7.31 g/plant) were found at par among themselves during the study. The data at 60 DAP under rainfed condition showed significant difference among different genotypes. AKSM-10(12.79 g/plant), recorded significantly highest total dry matter production followed by MCB-405(12.48g/plant), AKSM-7(11.97g/plant), AKSM-14(11.78 g/plant), AKSM-12(11.64 g/plant), AKSM-

5(11.57 g/plant), AKSM-11(11.24 g/plant) and found at par among themselves. Significantly lowest total dry matter production was noticed by the accession AKSM-3(10.01 g/plant) followed by AKSM-2(10.04 g/plant), AKSM-

4(10.40 g/plant), AKSM-6(10.43 g/plant), AKSM-9(10.55 g/plant), AKSM-1(10.67 g/plant), AKSM-8(10.72 g/plant), AKSM-15(10.99 g/plant) and AKSM-13(11.03 g/plant) and were found at par among themselves.

**Table 3:** Evaluation of local cultures of safed musli for morphophysiological and biochemical parameters.

| Germplasm | HI at harvest | Saponin at harvest | 30   | 45   | 60    | CGR 30-45 | CGR 45-60 | RGR 30-45 | RGR 45-60 | NAR 30 | NAR 60 |
|-----------|---------------|--------------------|------|------|-------|-----------|-----------|-----------|-----------|--------|--------|
| AKSM-1    | 40.40         | -                  | 5.38 | 7.86 | 10.67 | 6.35      | 5.67      | 34.1      | 16.4      | 0.052  | 0.055  |
| AKSM-2    | 38.35         | 7.15               | 3.38 | 6.09 | 10.04 | 4.90      | 9.30      | 18.0      | 33.8      | 0.053  | 0.096  |
| AKSM-3    | 39.65         | 7.04               | 6.31 | 7.31 | 10.01 | 4.35      | 6.97      | 51.3      | 29.7      | 0.034  | 0.087  |
| AKSM-4    | 40.20         | 6.70               | 4.34 | 5.54 | 10.40 | 3.53      | 11.17     | 17.4      | 40.2      | 0.045  | 0.050  |
| AKSM-5    | 38.10         | 6.98               | 5.61 | 7.90 | 11.57 | 4.63      | 6.21      | 26.6      | 19.1      | 0.058  | 0.077  |
| AKSM-6    | 41.50         | 6.94               | 5.09 | 7.22 | 10.43 | 6.17      | 7.63      | 14.1      | 28.9      | 0.069  | 0.101  |
| AKSM-7    | 37.60         | 7.35               | 5.53 | 7.22 | 11.97 | 4.82      | 9.96      | 21.8      | 32.4      | 0.068  | 0.109  |
| AKSM-8    | 43.20         | 8.60               | 5.26 | 7.60 | 10.72 | 8.35      | 8.72      | 16.0      | 25.7      | 0.057  | 0.098  |
| AKSM-9    | 40.36         | 7.00               | 5.29 | 6.62 | 10.55 | 4.16      | 8.65      | 27.5      | 30.2      | 0.070  | 0.088  |
| AKSM-10   | 34.74         | 6.74               | 4.72 | 7.80 | 12.79 | 7.88      | 10.71     | 41.4      | 32.1      | 0.058  | 0.139  |
| AKSM-11   | 42.04         | 7.24               | 5.21 | 6.24 | 11.24 | 7.85      | 11.80     | 36.2      | 49.8      | 0.054  | 0.091  |
| AKSM-12   | 43.01         | 7.35               | 4.89 | 7.00 | 11.64 | 5.55      | 11.85     | 22.6      | 43.1      | 0.076  | 0.104  |
| AKSM-13   | 37.52         | 6.59               | 3.80 | 5.03 | 11.03 | 2.72      | 10.35     | 23.7      | 40.0      | 0.060  | 0.177  |
| AKSM-14   | 40.25         | 7.02               | 3.70 | 5.94 | 11.78 | 3.89      | 8.13      | 19.1      | 31.9      | 0.054  | 0.120  |
| AKSM-15   | 41.03         | 6.96               | 5.10 | 8.04 | 10.99 | 7.55      | 9.24      | 16.7      | 29.4      | 0.132  | 0.049  |
| MCB-405   | 45.83         | 7.16               | 5.27 | 8.72 | 12.48 | 10.10     | 11.00     | 37.5      | 46.0      | 0.122  | 0.094  |
| F-Test    | S             | S                  | S    | S    | S     | S         | S         | S         | S         | S      | S      |
| SE(m)±    | 1.39          | 0.05               | 0.40 | 0.46 | 0.53  | 0.44      | 0.69      | 1.9       | 2.1       | 0.005  | 0.005  |
| CD at 5%  | 4.19          | 0.16               | 1.22 | 1.39 | 1.60  | 1.32      | 2.09      | 5.7       | 6.4       | 0.015  | 0.015  |

#### Crop growth rate ( $\text{g m}^{-2} \text{ day}^{-1}$ )

The data during 30-45 DAP under rainfed condition showed significant differences among different genotypes. MCB-405( $10.10 \text{ g/m}^2/\text{day}$ ) recorded significantly superior none of the genotypes surpassed for crop growth rate. Significantly lowest crop growth rate was noticed by the accession AKSM-13( $2.72 \text{ g/m}^2/\text{day}$ ) followed by AKSM-4( $3.53 \text{ g/m}^2/\text{day}$ ), AKSM-14( $3.89 \text{ g/m}^2/\text{day}$ ) and found at par among themselves followed by AKSM-9( $4.16 \text{ g/m}^2/\text{day}$ ), AKSM-3( $4.35 \text{ g/m}^2/\text{day}$ ), AKSM-5( $4.63 \text{ g/m}^2/\text{day}$ ), AKSM-7( $4.82 \text{ g/m}^2/\text{day}$ ), AKSM-2( $4.90 \text{ g/m}^2/\text{day}$ ), AKSM-12( $5.55 \text{ g/m}^2/\text{day}$ ), AKSM-6( $6.17 \text{ g/m}^2/\text{day}$ ), AKSM-1( $6.35 \text{ g/m}^2/\text{day}$ ), AKSM-15( $7.55 \text{ g/m}^2/\text{day}$ ), AKSM-11( $7.85 \text{ g/m}^2/\text{day}$ ), AKSM-10( $7.88 \text{ g/m}^2/\text{day}$ ), AKSM-8( $8.35 \text{ g/m}^2/\text{day}$ ). The data during 45-60 DAP under rainfed condition showed significant differences among different genotypes. AKSM-12( $11.85 \text{ g/m}^2/\text{day}$ ) recorded significantly highest crop growth rate followed by AKSM-11( $11.80 \text{ g/m}^2/\text{day}$ ), AKSM-4( $11.17 \text{ g/m}^2/\text{day}$ ), AKSM-16( $11.00 \text{ g/m}^2/\text{day}$ ), AKSM-10( $10.71 \text{ g/m}^2/\text{day}$ ), AKSM-13( $10.35 \text{ g/m}^2/\text{day}$ ), AKSM-7( $9.96 \text{ g/m}^2/\text{day}$ ) however, these genotypes found on par among themselves. Significantly lowest crop growth rate was noticed by the accession AKSM-1( $5.67 \text{ g/m}^2/\text{day}$ ) followed by AKSM-5( $6.21 \text{ g/m}^2/\text{day}$ ), AKSM-3( $6.97 \text{ g/m}^2/\text{day}$ ), AKSM-6( $7.63 \text{ g/m}^2/\text{day}$ ) however, these are found at par among themselves. AKSM-14( $8.13 \text{ g/m}^2/\text{day}$ ), AKSM-9( $8.65 \text{ g/m}^2/\text{day}$ ), AKSM-8( $8.72 \text{ g/m}^2/\text{day}$ ), AKSM-15( $9.24 \text{ g/m}^2/\text{day}$ ), AKSM-2( $9.30 \text{ g/m}^2/\text{day}$ ) were found at par among themselves.

#### Relative growth rate ( $\text{mg g}^{-1} \text{ day}^{-1}$ )

The data during 30-45 DAP under rainfed condition showed significant differences among different genotypes. AKSM-3( $51.3 \text{ mg/g/day}$ ) recorded significantly superior than all the genotypes under study for relative growth rate. Significantly lowest relative growth rate was noticed by the accession AKSM-6( $14.1 \text{ mg/g/day}$ ), however AKSM-8( $16.00$

$\text{mg/g/day}$ ), AKSM-15( $16.7 \text{ mg/g/day}$ ), AKSM-4( $17.4 \text{ mg/g/day}$ ), AKSM-2( $18 \text{ mg/g/day}$ ), AKSM-14( $19.1 \text{ mg/g/day}$ ) however these were found on par among themselves followed by AKSM-7( $21.6 \text{ mg/g/day}$ ), AKSM-12( $22.6 \text{ mg/g/day}$ ), AKSM-13( $23.7 \text{ mg/g/day}$ ), AKSM-5( $26.6 \text{ mg/g/day}$ ), AKSM-9( $27.5 \text{ mg/g/day}$ ). AKSM-1( $34.1 \text{ mg/g/day}$ ), AKSM-11( $36.2 \text{ mg/g/day}$ ), MCB-405( $37.5 \text{ mg/g/day}$ ), AKSM-10 ( $41.4 \text{ mg/g/day}$ ) recorded numerically better genotypes for RGR. The data during 45-60 DAP under rainfed condition showed significant differences among different genotypes, AKSM-11( $51.3 \text{ mg/g/day}$ ), recorded significantly superior highest relative growth rate followed by MCB-405( $46 \text{ mg/g/day}$ ) and found at par with each other. Significantly lowest relative growth rate was noticed by the accession AKSM-1( $16.4 \text{ mg/g/day}$ ), AKSM-5( $19.1 \text{ mg/g/day}$ ) and found on par with each other AKSM-8( $25.7 \text{ mg/g/day}$ ), AKSM-6( $28.9 \text{ mg/g/day}$ ), AKSM-15( $29.4 \text{ mg/g/day}$ ), AKSM-3( $29.7 \text{ mg/g/day}$ ), AKSM-9( $30.2 \text{ mg/g/day}$ ), AKSM-14( $31.9 \text{ mg/g/day}$ ), AKSM-10( $32.1 \text{ mg/g/day}$ ), AKSM-7( $32.4 \text{ mg/g/day}$ ), AKSM-2( $33.8 \text{ mg/g/day}$ ), AKSM-13( $40 \text{ mg/g/day}$ ), AKSM-4( $40.2 \text{ mg/g/day}$ ), AKSM-12( $43.1 \text{ mg/g/day}$ ) are found better performing genotypes under study.

AKSM-3 and AKSM-10 have seen highest RGR during early vegetative growth stage which reflects in higher vigour, healthy relative growth rate of safed musli which is an important parameter to observe during the evaluation of local culture of safed musli for morpho-physiological parameters under rainfed conditions because it provides valuable information about the plant's biomass accumulation and overall growth potential.

#### Net assimilation rate ( $\text{g dm}^{-2} \text{ day}^{-1}$ )

The data during 30-45 DAP under rainfed condition showed significant differences among genotypes. AKSM-15( $0.132 \text{ g/cm}^2/\text{day}$ ) recorded significantly highest net assimilation rate followed by MCB-405( $0.122 \text{ g/cm}^2/\text{day}$ ) and found on par with each other. Significantly lowest net

assimilation rate was noticed by the accession AKSM-3(0.034mg/g/day) followed by AKSM-4(0.045 g/cm<sup>2</sup>/day), AKSM-1(0.052g/cm<sup>2</sup>/day), AKSM-2(0.053 g/cm<sup>2</sup>/day), AKSM-11 and AKSM-14 each (0.054g/cm<sup>2</sup>/day), AKSM-8(0.057g/cm<sup>2</sup>/day), AKSM-5 and AKSM-10 each (0.058 g/cm<sup>2</sup>/day), AKSM-13(0.060 g/cm<sup>2</sup>/day) and found on par among themselves. AKSM-7(0.068 g/cm<sup>2</sup>/day), AKSM-6(0.069 g/cm<sup>2</sup>/day), AKSM-9(0.070g/cm<sup>2</sup>/day), AKSM-12(0.0760g/cm<sup>2</sup>/day) were recorded better NAR during vegetative growth stage.

The data during 45-60 DAP under rainfed condition showed significant differences among difference genotypes. AKSM-13(0.177 g/cm<sup>2</sup>/day) recorded significantly highest net assimilation than all the genotypes under study. Significantly lowest net assimilation rate was noticed by the accession AKSM-4 and AKSM-15 each (0.0490 g/cm<sup>2</sup>/day), AKSM-1(0.0552 g/cm<sup>2</sup>/day) and found on par among themselves followed by AKSM-5(0.077 g/cm<sup>2</sup>/day), AKSM-3(0.087 g/cm<sup>2</sup>/day), AKSM-9(0.088 g/cm<sup>2</sup>/day), AKSM-11(0.091 g/cm<sup>2</sup>/day) however found on par among themselves. MCB-405(0.094 g/cm<sup>2</sup>/day), AKSM-2(0.096 g/cm<sup>2</sup>/day), AKSM-8(0.098 g/cm<sup>2</sup>/day), AKSM-6(0.101 g/cm<sup>2</sup>/day), AKSM-12(0.104 g/cm<sup>2</sup>/day), AKSM-7(0.109 g/cm<sup>2</sup>/day) AKSM-14(0.120 g/cm<sup>2</sup>/day) and AKSM-10(0.139 g/cm<sup>2</sup>/day) were found better performer during reproductive stage (45 to 60 DAP) among different genotypes under study, however could not surpass accession AKSM-13 (0.177 g/cm<sup>2</sup>/day).

NAR parameter provides valuable information about the plant's ability to assimilate carbon through photosynthesis and allocate it towards growth and development. By monitoring the net assimilation rate, the plant's efficiency in converting carbon dioxide and light energy into organic compounds, which are essential for plant growth. This can help in understanding the plant's productivity and potential yield under rainfed conditions.

## Conclusions

The present study contributes to our understanding of plant physiology and ecology. It helps us useful information regarding AKSM-8 and MCB-405 genotype with respect to morphological, physiological, biochemical parameters and yield and yield attributing parameters. The present study may be useful for crop improvement and improving morpho-physiological and biochemical parameters to increase in safed musli yield, and benefit to farmers. The present study may be useful for future recommendation on the basis of different genotypes provides valuable information for farmers and breeders on the performance of different genotypes of Safed Musli under rainfed conditions and also improving morphological, physiological and biochemical parameters leading to increase in safed musli yield.

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